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DESCRIPTION

NON-CROSSLINKED FLAME-RETARDANT RESIN COMPOSITION, AND  
AN INSULATED WIRE AND A WIRING HARNESS USING THE SAME

TECHNICAL FIELD

The present invention relates to a non-crosslinked flame-retardant resin composition, and an insulated wire and a wiring harness using the same, and more specifically relates to a non-crosslinked flame-retardant resin composition suitable for an insulated covering material for an insulated wire used in parts for a car such as an automobile, electric/electronic equipment and the like, and an insulated wire and a wiring harness using the same.

BACKGROUND ART

Conventionally, for an insulated covering material for an insulated wire used in carrying out wiring of parts for a car such as an automobile, electric/electronic equipment and the like, generally in wide use is a vinyl chloride resin excellent in flame retardancy, into which, according to a variety of required properties including mechanical properties such as wear resistance, tensile strength and tensile elongation, flexibility, and workability, additives such as a plasticizer and a stabilizer are blended as appropriate and adjustments are made to types and blending amounts of the additives.

However, there is a problem that the vinyl chloride resin, having flame retardancy by itself, includes halogen elements in its molecular chains, so that it emits harmful halogenous gas into the atmosphere in case of car fire or at the time of combustion for disposing of electric /electronic equipment by incineration, causing environmental pollution.

Under the circumstances, developed these days has been a so-called non-halogenous flame-retardant resin composition, which is prepared by using polyethylene, polypropylene or the like as its base resin and adding a metallic hydrate such as magnesium hydroxide as a flame retardant; however, there is a disadvantage that mechanical properties such as wear resistance remarkably degrade since the non-halogenous flame-retardant resin composition requires a large amount of metallic hydrate to be added thereto as the flame retardant.

Thus, in order to overcome such a disadvantage, for example, Japanese Patent Gazette No. 3280099 discloses an art of using a plurality of polyolefin resins and rubbers as the base resin, in which a specific functional group is further contained by a specific amount so as to increase an affinity between the base resin and the metallic hydrate and improve mechanical properties such as wear resistance.

However, the following problems arise when the conventionally-known non-halogenous flame-retardant resin composition, especially, a non-crosslinked

flame-retardant resin composition is used as the insulated covering material for the insulated wire. Specifically, when the insulated covering material is used in areas exposed to high temperature environment such as an engine room in an automobile, there arises a problem that the insulated covering material is unintentionally molten.

In addition, as the insulated covering material for the insulated wire used in areas requiring high heat resistance is generally subjected to crosslinking such as electron irradiation crosslinking and silane crosslinking, there arises a problem that the cost of manufacturing is increased if dedicated equipment is employed in such crosslinking.

Besides, in the case of using the insulated wire in an automobile and the like, it is generally often the case that a plurality of insulated wires are tied into a wire bundle, around which a protective material in various shapes such as a tape, tube or sheet is wound to be utilized as a wiring harness.

At this time, as the insulated wires making up the wiring harness, not only non-halogenous insulated wires in which non-halogenous flame-retardant resin compositions are used as insulated covering materials are used, but also vinyl chloride insulated wires and the like in which vinyl chloride resin compositions such as polyvinyl chloride are used as insulated covering materials are abundantly used, empirically.

Therefore, mixed use of the non-halogenous insulated wires and the vinyl chloride insulated wires is difficult to completely avoid. Under these circumstances, it turned out that if the non-halogenous insulated wires are used in contact with the vinyl chloride insulated wires and the like, there arises a problem of remarkably deteriorating the insulated covering material for the non-halogenous insulated wires in the wire bundle to degrade heat resistance.

Further, since the vinyl chloride resin composition and the like are usually used as a base material for the wiring-harness protective material wound around the wire bundle, it turned out that the same problem arises if the non-halogenous insulated wire is used in contact with a vinyl-chloride wiring-harness protective material and the like.

Though a detailed mechanism of the sources of the problems is not found yet, those problems are assumed to arise because an antioxidant in the insulated covering material composed of the non-halogenous flame-retardant resin composition is remarkably consumed, or the antioxidant itself makes a transition into the vinyl chloride insulated wire or the vinyl-chloride wiring-harness protective material when the vinyl chloride insulated wire, the vinyl-chloride wiring-harness protective material or the like comes into contact with the non-halogenous insulated wire. At any

rate, there is a need to immediately solve these problems concerning deterioration.

Consequently, the present invention has been made in view of the above circumstances and has an object to overcome the above problems and to provide a non-crosslinked flame-retardant resin composition which possesses sufficient flame retardancy, mechanical properties, flexibility and workability, and also possesses excellent heat resistance over a long period of time as it is hard to be molten when used under high temperature environment and not deteriorated even if used in contact with a vinyl chloride resin material and the like.

In addition, another object of the invention is to provide a non-halogenous insulated wire using the above-described non-crosslinked flame-retardant resin composition as an insulated covering material, and a wiring harness including the non-halogenous insulated wire.

#### DISCLOSURE OF THE INVENTION

To achieve the objects and in accordance with the purpose of the present invention, as embodied and broadly described herein, a non-crosslinked flame-retardant resin composition consistent with the present invention includes (A) a non-crosslinked base resin which contains a propylene resin containing 50 wt% or more of propylene

monomer and a thermoplastic resin of which a melting point is 180°C or more, (B) a metallic hydrate, (C) a hindered phenolic antioxidant, (D) a sulfurous antioxidant, and (E) a metallic oxide.

At this time, it is preferable that the non-crosslinked base resin contains the propylene resin by 40-90 wt% and the thermoplastic resin of which a melting point is 180°C or more by 60-10 wt%.

In addition, the thermoplastic resin of which a melting point is 180°C or more is preferably polymethylpentene.

Here, preferable blending amounts of the respective ingredients are, with respect to 100 part weight of (A) the non-crosslinked base resin, 30-250 part weight of (B) the metallic hydrate, 0.3-15 part weight of (C) the hindered phenolic antioxidant, 0.3-30 part weight of (D) the sulfurous antioxidant, and 0.3-30 part weight of (E) the metallic oxide.

In addition, (D) the sulfurous antioxidant is preferably an imidazole compound.

In addition, (E) the metallic oxide is preferably an oxide of at least one metal selected from zinc (Zn), aluminum (Al), magnesium (Mg), lead (Pb) and tin (Sn).

In addition, (B) the metallic hydrate is preferably magnesium hydroxide or aluminum hydroxide.

Meanwhile, a non-halogenous insulated wire consistent with the present invention includes a conductor

covered with the non-crosslinked flame-retardant resin composition as mentioned above.

In addition, a wiring harness consistent with the present invention includes a single wire bundle including only the non-halogenous insulated wires or a mixed wire bundle including at least the non-halogenous insulated wires and vinyl chloride insulated wires, and a wiring-harness protective material for covering the wire bundle, in which a non-halogenous resin composition, a vinyl chloride resin composition or a halogenous resin composition other than the vinyl chloride resin composition is used as a base material.

According to the non-crosslinked flame-retardant resin composition consistent with the present invention, including (A) the non-crosslinked base resin which contains the propylene resin containing 50 wt% or more of propylene monomer and the thermoplastic resin of which a melting point is 180°C or more, (B) the metallic hydrate, (C) the hindered phenolic antioxidant, (D) the sulfurous antioxidant and (E) the metallic oxide, sufficient flame retardancy, mechanical properties, flexibility and workability are delivered while halogenous gas is not emitted at the time of combustion, and at the same time, sufficient heat resistance over a long period of time is delivered as the non-crosslinked flame-retardant resin composition is hard to be molten when used under high temperature environment and its material is not

deteriorated even if used in contact with the vinyl chloride resin material and the like.

Further, according to the non-halogenous insulated wire consistent with the present invention in which the above-described non-crosslinked flame-retardant resin composition is used as an insulated covering material and the wiring harness consistent with the present invention in which the non-halogenous insulated wire is included in its wire bundle, heat resistance is sufficiently delivered over a long period of time as the insulated covering material does not remarkably deteriorate even in the case of using the non-halogenous insulated wire in contact with the vinyl chloride insulated wire in the wire bundle or in contact with the vinyl-chloride wiring-harness protective material covering the wire bundle or a halogenous wiring-harness protective material other than the vinyl-chloride wiring-harness protective material. In addition, it is not necessary to subject the insulated wiring material to crosslinking which results in high cost for the purpose of obtaining sufficient heat resistance.

Therefore, if the non-halogenous insulated wire and the wiring harness consistent with the present invention are used in areas constantly exposed to high temperature environment such as an engine room of an automobile, high reliability over a long period of time can be ensured at low cost.



### BEST MODE FOR CARRYING OUT THE INVENTION

A detailed description of one preferred embodiment of the present invention will now be given. A non-crosslinked flame-retardant resin composition consistent with the present invention includes (A) a non-crosslinked base resin which contains a propylene resin containing 50 wt% or more of propylene monomer and a thermoplastic resin of which a melting point is 180°C or more (hereinafter referred to as a "high melting point resin", (B) a metallic hydrate, (C) a hindered phenolic antioxidant, (D) a sulfurous antioxidant, and (E) a metallic oxide. Firstly, a description concerning the respective ingredients of the non-crosslinked flame-retardant resin composition consistent with the present invention is given.

In the present invention, the propylene resin in (A) the non-crosslinked base resin refers to the one which contains 50 wt% or more of propylene monomer. The content of propylene monomer is preferably 70 wt% or more since excellent mechanical properties are delivered. Here, the propylene resin may contain the propylene monomer alone, or may contain one or more sorts of monomers other than the propylene monomer as appropriate.

For those other monomers, named are ethylene, alpha-olefin (C3-C20), unconjugated polyene, and the like.

For the alpha-olefin (C3-C20), named are propylene, 1-butene, 1-hexene, 1-heptene, 1-octane, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, 1-hexadecene, 1-heptadecene, 1-nonadecene, 1-eicosene, 9-methyl-1-decene, 11-methyl-1-dodecene, 12-ethyl-1-tetradecene, and the like. In addition, for the above-described unconjugated polyene, named are dicyclopentadiene, ethylidenenorbornene, and the like.

Besides, it is desirable for the above-described propylene resin to have a melt flow rate (MFR) measured based on JIS K 6758 (measurement is performed at 230°C under a load of 2.16 kg) within the range of 0.1-7 g/10 minutes, preferably 0.3-5 g/10 minutes. This is because in a case where the MFR is below 0.1 g/10 minutes, the resin composition demonstrates a tendency to degrade its fluidity, and in a case where the MFR is over 7 g/10 minutes, it demonstrates a tendency to degrade mechanical properties and the like.

In contrast, for the high melting point resin in (A) the non-crosslinked base resin, the melt flow rate (MFR), density and the like are not particularly limited, and specifically named are polymethylpentene (with a melting point of 220-240°C) and the like.

In addition, it is desirable for (A) the non-crosslinked base resin to contain the propylene resin within the range of 40-90 wt% and the high melting point

resin within the range of 60-10 wt%, preferably the propylene resin within the range of 50-85 wt% and the high melting point resin within the range of 50-15 wt%. This is because a tendency of not obtaining sufficient mechanical properties is demonstrated in a case where the content of propylene resin is less than 40 wt% and a tendency of not obtaining sufficient heat resistance in a case where the content of the high melting point resin is less than 10 wt%.

For (B) the metallic hydrate which is utilized as a flame retardant in the present invention, specifically named are compounds having a hydroxyl group or crystalline water, such as magnesium hydroxide, aluminum hydroxide, zirconium hydroxide, hydrated magnesium silicate, hydrated aluminum silicate, magnesium carbonate and hydro talcite, which may be employed by one sort alone or more than one sort in combination. Among them, magnesium hydroxide and aluminum hydroxide are especially preferable since they have a high degree of effectiveness in flame retardancy and heat resistance, and also have cost effectiveness.

At this time, it is desirable for the above-described magnesium hydroxide, aluminum hydroxide and the like to have an average particle size ( $d_{50}$ ) within the range of 0.4-5.0  $\mu\text{m}$ , preferably within the range of 0.5-2.0  $\mu\text{m}$ , though particle sizes of the metallic hydrates differ depending on the variety. This is because in a case where

the average particle size is smaller than  $0.4\mu\text{m}$ , secondary cohesion between particles occurs to demonstrate a tendency to degrade mechanical properties, and in a case where the average particle size is larger than  $0.5\mu\text{m}$ , mechanical properties are degraded to demonstrate a tendency to give rise to surface roughness when used as an insulated covering material.

In addition, (B) the metallic hydrate consistent with the present invention may be subjected to surface finishing using a finishing agent such as a fatty acid, fatty-acid metallic salt, a silane coupling agent and a titanate coupling agent. Besides, in the case of employing a surface-finished metallic hydrate, a metallic hydrate which is previously subjected to surface finishing using a finishing agent may be blended into the composition, or an unfinished metallic hydrate may be blended into the composition together with a finishing agent to be subjected to surface finishing, which is not limited in particular.

For (C) the hindered phenolic antioxidant consistent with the present invention, named are pentaerythritol tetrakis [3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate]; thiodiethylenebis[3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate]; octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate; N,N'-hexane-1,6-diylbis [3-(3,5-di-tert-butyl-4-hydroxyphenyl propione amide)]; benzene propanoic acid, 3,5-bis(1,1-

dimethylethyl)-4-hydroxy,C7-C9 side-chain alkyl ester;  
 2,4-dimethyl-6-(1-methyl pentadecyl) phenol; diethyl  
 [[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl] methyl]  
 phosphonate; 3,3',3'',5,5',5''-hexa-tert-butyl-a,a',a''-  
 (mesitylene-2,4,6-triyl) tri-p-cresol; calcium  
 diethylbis [[[3,5-bis(1,1-dimethylethyl)-4-  
 hydroxyphenyl] methyl] phosphonate]; 4,6-bis  
 (octylthiomethyl)-o-cresol; ethylenebis (oxyethylene)  
 bis [3-(5-tert-butyl-4-hydroxy-m-tolyl) propionate];  
 hexamethylenebis [3-(3,5-di-tert-butyl-4-  
 hydroxyphenyl) propionate; 1,3,5-tris(3,5-di-tert-  
 butyl-4-hydroxybenzyl)-1,3,5-triazine-2,4,6(1H,3H,5H  
 )-trione; 1,3,5-tris[(4-tert-butyl-3-hydroxy-2,6-  
 xylyl) methyl]-1,3,5-triazine-2,4,6(1H,3H,5H)-trione;  
 2,6-tert-butyl-4-(4,6-bis(octylthio)-1,3,5-triazine-  
 2-ylamino) phenol; 2,6-di-tert-butyl-4-methylphenol;  
 2,2'-methylenebis(4-methyl-6-tert-butylphenol);  
 4,4'-butylidenebis(3-methyl-6-tert-butylphenol);  
 4,4'-thiobis(3-methyl-6-tert-butylphenol); 3,9-bis  
 [2-(3-(3-tert-butyl-4-hydroxy-5-methylphenyl))-1,1-  
 dimethylethyl]-2,4,8,10-tetraoxaspiro (5,5) undecane;  
 and the like, which may be employed by one sort alone  
 or more than one sort in combination.

Among them, especially preferable ones are  
 pentaerythritol tetrakis [3-(3,5-di-tert-butyl-4-  
 hydroxyphenyl) propionate]; 3,3',3'',5,5',5''-hexa-tert-  
 butyl-a,a',a''-(mesitylene-2,4,6-triyl) tri-p-cresol;

and 1,3,5-tris (3,5-di-tert-butyl-4-hydroxybenzyl)-1,3,5-triazine-2,4,6(1H,3H,5H)-trione.

For (D) the sulfurous antioxidant consistent with the present invention, named are an imidazole compound, a thiazole compound, a sulfenamid compound, a thiuram compound, a dithiocarbamate compound, a xanthate compound and the like, which may be employed by one sort alone or more than one sort in combination. Besides, the imidazole compound referred to in the present invention includes an atom of sulfur (S).

For the imidazole compound, named are 2-mercaptobenzimidazole, 2-mercaptomethylbenzimidazole, 4-mercaptomethylbenzimidazole, 5-mercaptomethylbenzimidazole and the like, and zinc salts thereof.

In addition, for the thiazole compound, named are 2-mercaptobenzthiazole; di-2-benzthiazole disulfide; zinc salt of 2-mercaptobenzthiazole; cyclohexylamine salt of 2-mercaptobenzthiazole; 2-(N,N-diethylthiocarbamoylthio)benzthiazole; 2-(4'-morpholinodithio)benzthiazole; and the like.

In addition, for the sulfenamid compound, named are N-cyclohexyl-2-benzthiazolesulfenamid; N-tert-butyl-2-benzthiazolesulfenamid; N-oxydiethylene-2-benzthiazolesulfenamid; N,N-diisopropyl-2-benzthiazolesulfenamid;

N,N'-dicyclohexyl-2-benzthiazolesulfenamid; and the like.

In addition, for the thiuram compound, named are tetramethylthiuram monosulfide, tetramethylthiuram disulfide, tetraethylthiuram disulfide, tetrabutylthiuram disulfide, dipentamethylenethiuram tetrasulfide, tetrakis(2-ethylhexyl)thiuramdisulfide, and the like.

In addition, for the dithiocarbamate compound, named are zinc dimethyldithiocarbamate, zinc diethyldithiocarbamate, zinc-di-n-butylthiocarbamate, zinc-N-ethyl-N-phenyldithiocarbamate, zinc-N-pentamethylenedithiocarbamate, zinc dibenzylthiocarbamate, and the like.

In addition, for the xanthate compound, named are sodium isopropyl xanthate, zinc isopropyl xanthate, zinc butyl xanthate, and the like.

Among the sulfurous antioxidants named above, the imidazole compound is preferable, and especially, 2-mercaptobenzimidazole, 2-mercaptomethylbenzimidazole and zinc salt of 2-mercaptomethylbenzimidazole are preferable.

For (E) the metallic oxide consistent with the present invention, named are an oxide of a metal such as zinc (Zn), aluminum (Al), magnesium (Mg), lead (Pb) and tin (Sn), an oxide of an alloy of the above-described metals,

and the like, which may be employed by one sort alone or more than one sort in combination. Among these oxides, the oxide of zinc (Zn) is especially preferable.

Blending amounts of the ingredients (A)-(E) consistent with the present invention are preferably, with respect to 100 part weight of (A) the non-crosslinked base resin, 30-250 part weight of (B) the metallic hydrate, 0.3-15 part weight of (C) the hindered phenolic antioxidant, 0.3-30 part weight of (D) the sulfurous antioxidant, and 0.3-30 part weight of (E) the metallic oxide.

At this time, it is not preferable for the blending amount of (B) the metallic hydrate to be less than 30 part weight since a tendency that sufficient flame retardancy is not obtained is demonstrated and more than 250 part weight since a tendency that sufficient mechanical properties are not obtained is demonstrated. A more preferable blending amount of (B) the metallic hydrate is within the range of 50-200 part weight with respect to 100 part weight of (A) the non-crosslinked base resin.

In addition, it is not preferable for the blending amount of (C) the hindered phenolic antioxidant to be less than 0.3 part weight since a tendency that sufficient heat resistance is not obtained is demonstrated and more than 15 part weight since a tendency that its blending effect becomes saturated as well as a tendency that an



additive exudes to the surface of the composition during use are demonstrated. A more preferable blending amount of (C) the hindered phenolic antioxidant is within the range of 0.5-10 part weight with respect to 100 part weight of (A) the non-crosslinked base resin.

In addition, it is not preferable for the blending amount of (D) the sulfurous antioxidant to be less than 0.3 part weight since a tendency that sufficient heat resistance is not obtained is demonstrated and more than 30 part weight since a tendency that its blending effect becomes saturated as well as a tendency that an additive exudes to the surface of the composition during use are demonstrated. A more preferable blending amount of (D) the sulfurous antioxidant is within the range of 0.5-20 part weight with respect to 100 part weight of (A) the non-crosslinked base resin.

In addition, it is not preferable for the blending amount of (E) the metallic oxide to be less than 0.3 part weight since a tendency that sufficient heat resistance is not obtained is demonstrated and more than 30 part weight since a tendency that its blending effect becomes saturated as well as a tendency that sufficient mechanical properties are not obtained are demonstrated. A more preferable blending amount of (E) the metallic oxide is within the range of 0.5-20 part weight with respect to 100 part weight of (A) the non-crosslinked base resin.

While the detailed description regarding the

essential ingredients (A)-(E) of the present invention is given as above, the non-crosslinked flame-retardant resin composition consistent with the present invention may be used in combination with polyolefin or a rubber as an arbitrary resin ingredient as appropriate. For the polyolefin, named are low-density polyethylene by a high-pressure radical polymerization method; ethylene-alpha-olefin copolymer; ethylene-vinylester copolymer; ethylene-alpha, beta-unsaturated carboxylic acid alkyl ester copolymer; and the like. In addition, for the rubber, named are an ethylene propylene rubber, a butadiene rubber, an isoprene rubber, a crude rubber, a nitrile rubber, an isobutylene rubber, and the like. These polyolefin and rubbers may be used alone or in combination.

For alpha-olefin copolymer used for the ethylene-alpha-olefin copolymer, the one obtained by a low/moderate pressure process using Ziegler catalyst, single-site catalyst or the like, or other known processes is utilized, and for alpha-olefin, named are ethylene and alpha-olefin (C3-20), and more specifically, propylene, 1-butene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, 1-hexadecene, 1-heptadecene, 1-nonadecene, 1-eicosene, 9-methyl-1-decene, 11-methyl-1-dodecene, 12-ethyl-1-tetradecene, and the like.

For vinylester monomer used for the ethylene-

vinylester copolymer, named are vinyl propionate, vinyl acetate, vinyl caproate, vinyl caprylate, vinyl laurate, vinyl stearate, vinyl trifluoroacetate, and the like.

For alpha, beta-unsaturated carboxylic acid alkyl ester monomer used for the ethylene-alpha, beta-unsaturated carboxylic acid alkyl ester copolymer, named are methyl acrylate, methyl methacrylate, ethyl acrylate, ethyl methacrylate, and the like.

For the ethylene propylene rubber, named are random copolymer mainly composed of ethylene and propylene, random copolymer mainly composed of ethylene and propylene to which diene monomer such as dicyclopentadiene and ethylidenenorbornene is added as a third ingredient, and the like.

For the butadiene rubber, which refers to copolymer including butadiene, named are styrene-butadiene block copolymer; styrene-ethylene-butadiene-styrene copolymer which is a hydrogenated or partially-hydrogenated derivative of the styrene-butadiene block copolymer; 1,2-polybutadiene; maleic-anhydride modified styrene-ethylene-butadiene-styrene copolymer; a modified butadiene rubber with a core-shell structure; and the like.

For the isoprene rubber, which refers to copolymer including isoprene, named are styrene-isoprene block copolymer, styrene-ethylene-isoprene-styrene copolymer which is a hydrogenated or partially-hydrogenated

derivative of the styrene-isoprene block copolymer, maleic-anhydride modified styrene-ethylene-isoprene-styrene copolymer, a modified isoprene rubber with a core-shell structure, and the like.

At this time, the above-described polyolefin or rubber is contained within the range of 0-70 part weight with respect to 100 part weight of (A) the non-crosslinked base resin. The blending amount of polyolefin or rubber exceeding the upper limit is not preferable because a tendency to degrade mechanical properties and the like is demonstrated.

In addition, in the non-crosslinked flame-retardant resin composition consistent with the present invention, other additives may be blended as appropriate insofar as physical properties of the composition are not impaired. Specifically, additives and the like generally used for a resin molding material such as an inorganic filler, antioxidants other than the above-described antioxidants, a metal deactivator (copper inhibitor), an ultraviolet absorber, an ultraviolet-concealing agent, a flame-retardant auxiliary agent, a processing aid (lubricant, wax and the like), and carbon and other coloring pigments may be blended, and are not limited in particular hereto.

For example, blending the inorganic filler as the additive allows the blending amount of (B) the metallic hydrate being the flame retardant to be decreased, and

allows other properties to be provided. For the inorganic filler, specifically named are calcium sulfate, calcium silicate, clay, diatomaceous earth, talc, silicate sand, glass powder, iron oxide, graphite, silicon carbide, silicon nitride, silica, boron nitride, aluminum nitride, carbon black, mica, a glass plate, sericite, pyrophyllite, Shirasu-balloon, glass balloon, pumice, glass fiber, carbon fiber, whisker, graphite fiber, silicon carbide fiber, asbestos, wallastonite, and the like.

In addition, in the non-crosslinked flame-retardant resin composition consistent with the present invention, a functional group generally used to improve various physical properties may be introduced to its non-crosslinked base resin since it does not impair flame retardancy and heat resistance being essential properties of the present invention. For the functional group, specifically named are a carboxylic acid group, an acid anhydrous group, an epoxy group, a hydroxyl group, an amino group, an alkenyl cyclic imino ether group, a silane group, and the like.

A production process of the non-crosslinked flame-retardant resin composition consistent with the present invention is not limited in particular, and a publicly known production process may be adopted. For example, the composition may be obtained by blending the essential ingredients (A)-(E), and the above-described arbitrary resin ingredient and additives as appropriate,

and dry-blending them through the use of a regular tumbler and the like, or melting and kneading them to disperse uniformly through the use of a regular kneader such as a Banbury mixer, a pressure kneader, a kneading extruder, a twin-screw extruder and a roll.

Next, a detailed description is given to the effect of the non-crosslinked flame-retardant resin composition consistent with the present invention.

As the non-crosslinked flame-retardant resin composition with the above-described constitution includes (A) the non-crosslinked base resin which contains the propylene resin containing 50 wt% or more of propylene monomer and the high melting point resin, (B) the metallic hydrate, (C) the hindered phenolic antioxidant, (D) the sulfurous antioxidant and (E) the metallic oxide, sufficient flame retardancy, mechanical properties such as wear resistance, tensile strength and tensile elongation, flexibility, and workability are delivered while halogenous gas is not emitted at the time of combustion, and at the same time, sufficient heat resistance over a long period of time is delivered as the non-crosslinked flame-retardant resin composition is hard to be molten when used under high temperature environment and the material is not deteriorated even if used in contact with the vinyl chloride resin material and the like. Here, as long as the respective ingredients are blended within the above-described specific ranges,

the respective properties become excellent in balance.

Especially in a case where the non-crosslinked flame-retardant resin composition is employed as an insulated covering material for non-halogenous insulated wires and these non-halogenous insulated wires are used in contact with vinyl chloride insulated wires in a wire bundle or in contact with a vinyl-chloride wiring-harness protective material covering the wire bundle, the insulated covering material for the non-halogenous insulated wires does not remarkably deteriorate and delivers sufficient heat resistance over a long period of time even if crosslinking is not made thereto.

Here, a matter of great import in the present invention is that (C) the hindered phenolic antioxidant, (D) the sulfurous antioxidant and (E) the metallic oxide are contained as a set in (A) the non-crosslinked base resin including the propylene resin and the high melting point resin, which contains (B) the metallic hydrate.

In other words, the above-described advantage unique to the present invention is not produced even in a case where the two ingredients of (C) the hindered phenolic antioxidant and (D) the sulfurous antioxidant are contained in (A) the non-crosslinked base resin which contains (B) the metallic hydrate, not to speak of a case where (C) the hindered phenolic antioxidant is contained therein alone, but produced only in a case where the three ingredients of (C) the hindered phenolic antioxidant,

(D) the sulfurous antioxidant and (E) the metallic oxide are contained therein.

Concerning this matter, it is conventionally known that use of a phenolic antioxidant and a sulfurous antioxidant in combination for a rubber material brings about a synergistic effect to performance at high temperatures. However, in the non-crosslinked base resin including the propylene resin and the high melting point resin which have totally different molecular structures as in the present invention, the synergistic effect shown in the rubber material is not expected at all only by using (C) the hindered phenolic antioxidant and (D) the sulfurous antioxidant in combination.

In contrast, even in the non-crosslinked base resin including the propylene resin and the high melting point resin as above, if (E) the metallic oxide is present in the base resin further to (C) the hindered phenolic antioxidant and (D) the sulfurous antioxidant, the material does not deteriorate apparently over a long period of time, so that heat resistance is improved.

Therefore, in the non-crosslinked flame-retardant resin composition consistent with the present invention, though a detailed mechanism is not found yet, it is assumed that (E) the metallic oxide acts as a catalyst for (D) the sulfurous antioxidant, allowing a synergistic effect and the like to be produced by (C) the hindered phenolic antioxidant and (D) the sulfurous antioxidant also in



the non-crosslinked base resin including the propylene resin and the high melting point resin, so that the above-described advantage unique to the present invention is produced. In addition, owing to the high melting point resin (a thermoplastic resin with a melting point of 180°C or more) contained, the non-crosslinked flame-retardant resin composition is made hard to be molten when constantly exposed to high temperature environment and excellent in heat deformation resistance.

Next, a description is given to constitution of a non-halogenous insulated wire and a wiring harness consistent with the present invention.

The non-halogenous insulated wire consistent with the present invention is a wire in which the above-described non-crosslinked flame-retardant resin composition is used as an insulated covering material. In constituting the non-halogenous insulated wire, a conductor may be directly covered with the insulated covering material, or another intermediate material such as a shielded conductor and another insulator may be interposed between the conductor and the insulated covering material.

In addition, the diameter, material and the like of the conductor are not limited in particular, which may be determined appropriately as usage. The thickness of the insulated covering material is neither limited in particular and may be determined appropriately in

consideration of the conductor diameter and the like.

As for a production process of the above-described non-halogenous insulated wire, it may be produced by extrusion covering the conductor, through the use of a generally-used extrusion molding machine and the like, with the non-crosslinked flame-retardant resin composition consistent with the present invention obtained by melting and kneading through the use of the generally-used kneader such as a Banbury mixer, a pressure kneader and a roll, and the process is not limited in particular.

On the other hand, the wiring harness consistent with the present invention is prepared by covering a single wire bundle including only the above-described non-halogenous insulated wires, or a mixed wire bundle including at least the above-described non-halogenous insulated wires and vinyl chloride insulated wires, with a wiring-harness protective material.

Here, the vinyl chloride insulated wire referred to in the present invention is a wire in which a vinyl chloride resin composition is used as an insulated covering material. Here, a vinyl chloride resin refers to a resin mainly consisting of vinyl chloride monomer, and this resin may be homopolymer of vinyl chloride or copolymer with another monomer. For the vinyl chloride resin, specifically named are polyvinyl chloride, ethylene-vinyl chloride copolymer, propylene-vinyl chloride

copolymer, and the like.

Incidentally, descriptions about constitution of the vinyl chloride insulated wire except for the insulated covering material and production process of the wire are omitted since they are almost the same as those of the above-described non-halogenous insulated wire.

In addition, the single wire bundle referred to in the present invention is a wire bundle made by tying only the above-described non-halogenous insulated wires into a bundle, while the mixed wire bundle, which includes at least the above-described non-halogenous insulated wires and the vinyl chloride insulated wires, is a wire bundle made by tying these mixed insulated wires into a bundle. At this time, the numbers of the wires included in the single wire bundle and the mixed wire bundle, respectively, may be determined arbitrarily, which are not limited in particular.

In addition, the wiring-harness protective material referred to in the present invention covers the wire bundle made by tying numbers of insulated wires, so as to play a role in protecting the inside wire bundle from an external environment and the like.

In the present invention, utilized as a base material constituting the wiring-harness protective material is a non-halogenous resin composition, a vinyl chloride resin composition, or a halogenous resin composition other than the vinyl chloride resin composition.

Utilized as the non-halogenous resin composition may be a polyolefin flame-retardant resin composition prepared by adding various additives such as a non-halogenous flame retardant to polyolefin such as polyethylene, polypropylene and propylene-ethylene copolymer, the above-described non-crosslinked flame-retardant resin composition consistent with the present invention, or the like.

In addition, used as the vinyl chloride resin composition may be the one described above as the vinyl chloride insulated wire material.

In addition, for the halogenous resin composition other than the vinyl chloride resin composition, named is a composition prepared by adding various additives such as a halogenous flame retardant to the above-described polyolefin, and the like.

In addition, for the wiring-harness protective material, one having a tape-shaped base material at least one side of which an adhesive is applied on, one having a base material which is tube-shaped, sheet-shaped or shaped otherwise, or the like may be used while appropriately selected as usage.

Incidentally, the wiring harness consistent with the present invention includes a variety of wiring harnesses as described below made by combining the above-described various wire bundles and the above-described various wiring-harness protective materials.

Specifically, the wiring harness consistent with the present invention includes one which is made by covering the single wire bundle including only the non-halogenous insulated wires with the vinyl-chloride wiring-harness protective material, one which is made by covering the single wire bundle including only the non-halogenous insulated wires with the non-halogenous wiring-harness protective material, one which is made by covering the single wire bundle including only the non-halogenous insulated wires with the halogenous wiring-harness protective material, one which is made by covering the mixed wire bundle including at least the non-halogenous insulated wires and the vinyl chloride insulated wires with the vinyl-chloride wiring-harness protective material, one which is made by covering the mixed wire bundle including at least the non-halogenous insulated wires and the vinyl chloride insulated wires with the non-halogenous wiring-harness protective material, and one which is made by covering the mixed wire bundle including at least the non-halogenous insulated wires and the vinyl chloride insulated wires with the halogenous wiring-harness protective material.

Next, a description is given to the effect of the non-halogenous insulated wire and the wiring harness consistent with the present invention.

According to the non-halogenous insulated wire consistent with the present invention and the wiring

harness consistent with the present invention, which includes the non-halogenous insulated wire in the wire bundle, the insulated covering material does not remarkably deteriorate even if the non-halogenous insulated wire is used in contact with the vinyl chloride insulated wire in the wire bundle or in contact with the vinyl-chloride wiring-harness protective material covering the wire bundle or the halogenous wiring-harness protective material other than the vinyl-chloride wiring-harness protective material, so that heat resistance is sufficiently delivered over a long period of time. In addition, it is not necessary to subject the insulated wiring material to crosslinking which results in high cost for the purpose of obtaining sufficient heat resistance.

Therefore, by using the non-halogenous insulated wire and the wiring harness consistent with the present invention in areas constantly exposed to high temperature environment such as an engine room of an automobile, high reliability over a long period of time may be ensured at low cost.

#### Example

A description of the present invention will now be given specifically with reference to Examples, however, the present invention is not limited hereto.

(Test Material, Manufacturer, and the like)

Test materials used in the Examples are given along

with manufacturers, trade names, values of physical properties, and the like. Besides, some of them used here were synthesized in a laboratory.

(A) Non-crosslinked Base Resin:

(a1) Polypropylene [manuf.: Idemitsu Petrochemical Co., Ltd., trade name: "E-150GM", MFR = 0.5 g/10 min.];

(a2) Polypropylene [manuf.: Japan Polychem Corporation, trade name: "BC8", MFR = 1.8 g/10 min.]; and

(a'1) Polymethylpentene [manuf.: Mitsui Chemicals, Inc., trade name: "MX002"]

(B) Metallic Hydrate:

(b1) Magnesium hydroxide [manuf.: Martinswerk GmbH, trade name: "MAGNIFIN H10", average particle size: 1.0  $\mu\text{m}$ ];

(b2) Magnesium hydroxide [manuf.: Showa Denko K.K., trade name: "HIGILITE H42", average particle size: 1.0  $\mu\text{m}$ ];

(b3) Magnesium hydroxide [reagent, average particle size: 0.5  $\mu\text{m}$ ];

(b4) Magnesium hydroxide [reagent, average particle size: 5.0  $\mu\text{m}$ ];

(b5) Magnesium hydroxide [reagent, average particle size: 0.3  $\mu\text{m}$ ]; and

(b6) Magnesium hydroxide [reagent, average particle size: 8.0  $\mu\text{m}$ ]

(C) Hindered Phenolic Antioxidant:

(c1) Manuf.: Ciba Specialty Chemicals Inc., trade name: "Irganox 1010";

(c2) Manuf.: Ciba Specialty Chemicals Inc., trade name:

"Irganox 3114";

(c3) Manuf.: Ciba Specialty Chemicals Inc., trade name:  
"Irganox 1076"; and

(c4) Manuf.: Asahi Denka Co., Ltd., trade name: "ADK AO-80"

(D) Sulfurous Antioxidant:

(d1) 2-mercaptobenzimidazole [manuf.: Ouchishinko  
Chemical Industrial Co., Ltd., trade name: "NOCRAC MB"];

(d2) 2-mercaptomethylbenzimidazole [manuf.: Ouchishinko  
Chemical Industrial Co., Ltd., trade name: "NOCRAC MMB"];

and

(d3) Zinc salt of 2-mercaptobenzimidazole [manuf.:  
Ouchishinko Chemical Industrial Co., Ltd., trade name:  
"NOCRAC MBZ"]

(E) Metallic Oxide:

(e1) Zinc oxide (zinc flower) [manuf.: Hakusui Tech Co.,  
Ltd., trade name: "Zinc Oxide JIS2"]

Other Ingredients:

(x1) Manuf.: Asahi Kasei Chemicals Corporation, trade  
name: "Tuftec H1041";

(x2) Manuf.: Asahi Kasei Chemicals Corporation, trade  
name: "Tuftec M1913";

(x3) Manuf.: KRATON Polymers Japan Ltd., trade name:  
"FG1901X";

(x4) Manuf.: Asahi Kasei Chemicals Corporation, trade  
name: "Tuftec H1053";

(x5) Manuf.: Du Pont-Mitsui Polychemicals Co., Ltd., trade  
name: "HPR VR103"; and



(y1) Manuf.: Ciba Specialty Chemicals Inc., trade name:  
"Irganox MD1024"

Besides, (x1)-(x5) are polyolefin or a rubber, and  
(y1) is a metal deactivator.

Vinyl Chloride Insulated Wire Material and Wiring-Harness  
Protective Material:

Polyvinyl chloride resin [manuf.: Toso Corporation, trade  
name: "4000M3", polymerization degree: 1300];

Diisononyl phthalate (DINP) [manuf.: Dainippon Ink and  
Chemicals Incorporated, trade name: "Monocizer DINP"];

Dioctyl Phthalate (DOP) [manuf.: Dainippon Ink and  
Chemicals Incorporated, trade name: "Monocizer DOP"];

Calcium carbonate heavy [manuf.: Maruo Calcium Co., Ltd.,  
trade name: "Super #1700"];

Calcium-zinc stabilizer [manuf.: Sakai Chemical Industry  
Co., Ltd., trade name: "OW-800"];

Styrene butadiene rubber [manuf.: JSR Corporation, trade  
name: "1013N"];

Crude rubber [RSS #2];

Zinc Oxide [manuf.: Hakusui Tech Co., Ltd., trade name:  
"Zinc Oxide JIS2"]; and

Rosinous resin [manuf.: Arakawa Chemical Industries, Ltd.,  
trade name: "Ester Gum H"]

(Preparation of Composition and Insulated Wire)

Firstly, by blending the respective ingredients  
presented in Tables shown later at a mixing temperature  
of 25°C through the use of a double-shaft kneader and

pelletizing them through the use of a pelletizing machine, compositions consistent with the present Examples and compositions consistent with Comparative Examples were obtained. Then, by extrusion-covering conductors (cross sectional area:  $0.5 \text{ mm}^2$ ), which were soft-copper twisted wires made by twisting seven soft copper wires together, with the obtained compositions to have a thickness of 0.28 mm through the use of a 50mm extruder, non-halogenous insulated wires consistent with the present Examples and non-halogenous insulated wires consistent with the Comparative Examples were prepared.

Next, 100 part weight of polyvinyl chloride resin (polymerization degree: 1300) was blended with 40 part weight of DINP (diisononyl phthalate) as a plasticizer, 20 part weight of calcium carbonate heavy as a filler, and 5 part weight of calcium-zinc stabilizer as a stabilizer at  $180^\circ\text{C}$  through the use of an open roll and pelletized through the use of a pelletizing machine to be formed into polyvinyl chloride resin compounds. With the compounds, conductors (cross sectional area:  $0.5 \text{ mm}^2$ ), which were soft-copper twisted wires made by twisting seven soft copper wires together, were extrusion-covered through the use of a 50mm extruder to have a thickness of 0.28 mm, and vinyl chloride insulated wires were prepared.

(Preparation of Wiring Harness)

Next, by using the obtained non-halogenous insulated

wires consistent with the present Examples, the obtained non-halogenous insulated wires and vinyl chloride insulated wires consistent with the Comparative Examples, wiring harnesses were prepared. To be more specific, the wiring harnesses were prepared by making mixed wire bundles of an arbitrary number of non-halogenous insulated wires and an arbitrary number of vinyl chloride insulated wires and winding the bundles with adhesive-backed tapes as wiring-harness protective materials.

At this time, the adhesive-backed tape was prepared so that an adhesive layer of 0.02 mm in thickness was provided as an adhesive all over a single surface of a base material composed of a polyvinyl chloride resin compound, and the thickness of the entire adhesive-backed tape was made to be 0.13 mm. Here, in preparing the polyvinyl chloride resin compound used as the material for the adhesive-backed tape, 100 part weight of polyvinyl chloride resin (polymerization degree: 1300) was blended with 60 part weight of DOP (dioctyl phthalate) as a plasticizer, 20 part weight of calcium carbonate heavy as a filler, and 5 part weight of calcium-zinc stabilizer as a stabilizer. In addition, in preparing the adhesive used, 70 part weight of styrene butadiene rubber was blended with 30 part weight of crude rubber, 20 part weight of zinc oxide, and 80 part weight of rosinous resin.

[Test Procedure]

The respective insulated wires prepared as above were

subjected to a flame-retardancy test, a tensile-elongation test, a tensile-strength test, a wear-resistance test, a flexibility test, a workability test, a heat-resistance A test and a heat-resistance C test, while the insulated wires in the wiring harness were subjected to a heat-resistance B test. Hereinafter, descriptions will be given to respective test procedures and respective assessment procedures.

(Flame-retardancy Test)

The flame-retardancy test was performed based on JASO D611-94. To be more specific, the non-halogenous insulated wires were cut into test specimens 300 mm long, each of which was placed in an iron test box to be held horizontal, and the tip of a reducing flame by a Bunsen burner having a caliber of 10 mm was placed beneath the center of the test specimen within 30 seconds until it burned, and then, after the flame was calmly removed, an afterflame time of the test specimen was measured. The test specimen whose afterflame time was within 15 seconds was regarded as passed, and the one whose afterflame time was over 15 seconds was regarded as failed.

(Tensile-elongation Test and Tensile-strength Test)

The tensile-elongation test and the tensile-strength test were performed based on JASO D611-94. To be more specific, the non-halogenous insulated wires were cut into specimens 150 mm long, from which the conductors were removed to be made into tubular test specimens

consisting only of the insulated covering materials, and then reference lines were marked at intervals of 50 mm along the center line. Next, at room temperatures of  $23 \pm 5^{\circ}\text{C}$ , the test specimen was attached by both ends to a chuck of a tensile tester to be pulled at a tensile speed of 200 mm/minute, and a load and a distance between the reference lines at the time when the test specimen was broken were measured. The test specimen whose tensile elongation was 125% or more was regarded as passed, and the one whose tensile elongation was below 125% was regarded as failed. Meanwhile, the test specimen whose tensile strength was 15.7 MPa or more was regarded as passed, and the one whose tensile strength was below 15.7 MPa was regarded as failed.

(Wear-resistance Test)

The wear-resistance test was performed by a blade-reciprocating method based on JASO D611-94. To be more specific, the non-halogenous insulated wires were cut into test specimens 750 mm long, and then at a room temperature of  $25^{\circ}\text{C}$ , a blade was made to reciprocate in a direction of its shaft over a length of 10 mm on a surface of the insulated covering material of each test specimen which was fixed to a table, and the number of reciprocation before the blade touches the conductor due to the wearing away of the insulated covering material was counted. At this time, a load imposed on the blade was set at 7N, and the blade was set to reciprocate at a speed of 50

times/minute. Then, the test specimen was moved by 100 mm and rotated 90 degrees clockwise, and the measurement as described above was repeated. The measurement was performed three times in total with respect to one test specimen, and the one whose smallest reciprocation number was 150 or more was regarded as passed, and the one whose smallest reciprocation number was below 150 was regarded as failed.

(Flexibility Test)

The flexibility test was performed by assessing the respective insulated wires by the touch when bending by hands. To be more specific, the one which had a good feel was regarded as passed and the one which had a bad feel was regarded as failed.

(Workability Test)

The workability test was performed by checking whether fringes were formed or not when resin-covered parts at the ends of the respective covered wires were stripped off, and the one which did not form a fringe was regarded as passed and the one which formed a fringe was regarded as failed.

(Heat-resistance A Test)

In the heat-resistance A test, one of the non-halogenous insulated wires was subjected to aging at 150°C for 72 hours, and then the wire was coiled to its own diameter. The one whose insulated covering material did not crack was regarded as passed and the

one whose insulated covering material cracked was regarded as failed.

(Heat-resistance B Test)

In the heat-resistance B test, the wiring harness, to be more specific, the wiring harness made by winding the vinyl chloride adhesive tape around the mixed wire bundle of an arbitrary number of non-halogenous insulated wires and an arbitrary number of vinyl chloride insulated wires, was subjected to aging at 150°C for 72 hours, and then an arbitrary non-halogenous insulated wire was taken out from the mixed wire bundle and coiled to its own diameter. The one whose insulated covering material did not crack was regarded as passed and the one whose insulated covering material cracked was regarded as failed.

(Heat-resistance C Test)

In the heat-resistance C test, the non-halogenous insulated wires were left standing for 10 minutes in a constant temperature oven at 200°C and then applied with pressure for 4 hours under a load of 300 g using a head with a top portion 0.7 mm in width. Then, the load was released, and a withstand voltage test (1000 volts for 1 minute) was performed on the non-halogenous insulated wires. The one which stood the withstand voltage test was regarded as passed and the one which did not stand the withstand voltage test was regarded as failed.

Ingredient constitution and assessment results of the compositions are shown in the following Tables 1-5.

[Table 1]

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Comparative example 1	Comparative example 2
(A) Non-crosslinked base resin (a1) E-150GM (a'1) MX002	70 30	70 30	70 30	70 30	70 30	70 30	70 30	70 30	70 30
(B) Metallic hydrate (b1) MAGNIFIN H10	70	70	70	70	70	70	70	70	70
(C) Hindered phenolic antioxidant (c1) Irganox 1010	3	3	3	3	3	3	3	3	3
(D) Sulfurous antioxidant (d1) NOCRAC MB (d2) NOCRAC MMB (d3) NOCRAC MBZ	5	5	5	5	5	0.5	20	0.1	25
(E) Metallic oxide (e1) Zinc Oxide JIS2	5	5	5	5	5	5	5	5	5
Other ingredients (x1) Tuftec H1041 (y1) Irganox MD1024	1	10 1	10 1	10 1	10 1	10 1	10 1	10 1	10 1
Flame retardancy	passed	passed	passed	passed	passed	passed	passed	passed	passed
Tensile elongation(%)	400	500	500	510	500	520	300	550	85
Tensile strength(MPa)	30	35	35	37	35	35	18	34	16
Wear resistance (number of times)	750	1200	1000	1000	900	1100	350	1200	350
Flexibility	passed	passed	passed	passed	passed	passed	passed	passed	passed
Workability	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance A	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance B(※)	passed	passed	passed	passed	passed	passed	passed	failed	failed
Heat resistance C	passed	passed	passed	passed	passed	passed	passed	passed	passed
※ Non-halogenous insulated wire (number of wires)	10	10	5	10	10	10	10	10	10
※ Vinyl chloride insulated wire (number of wires)	20	20	20	20	20	20	20	20	20



[Table 2]

	Example 8	Example 9	Comparative example 3	Comparative example 4
(A) Non-crosslinked base resin				
(a1) E-150GM	70	70	70	70
(a' 1) MX002	30	30	30	30
(B) Metallic hydrate				
(b1) MAGNIFIN H10	70	70	70	70
(C) Hindered phenolic antioxidant				
(c1) Irganox 1010	3	3	3	3
(D) Sulfurous antioxidant				
(d1) NOCRAC MB	5	5	5	5
(E) Metallic oxide				
(e1) Zinc Oxide JIS2	0.5	20	0.1	25
Other ingredients				
(x1) Tuftec H1041	10	10	10	10
(y1) Irganox MD1024	1	1	1	1
Flame retardancy	passed	passed	passed	passed
Tensile elongation(%)	500	350	480	300
Tensile strength(MPa)	38	25	36	21
Wear resistance	1000	800	1200	500
(number of times)				
Flexibility	passed	passed	passed	passed
Workability	passed	passed	passed	failed
Heat resistance A	passed	passed	failed	passed
Heat resistance B(※)	passed	passed	failed	passed
Heat resistance C	passed	passed	passed	passed
※ Non-halogenous insulated wire	10	10	10	10
(number of wires)				
※ Vinyl chloride insulated wire	20	20	20	20
(number of wires)				

[Table 3]

	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15	Comparative example 5	Comparative example 6	Comparative example 7	Comparative example 8
(A) Non-crosslinked base resin										
(a1) E-150GM	70	70	70	70	70	70	70	70	70	70
(a'1) MX002	30	30	30	30	30	30	30	30	30	30
(B) Metallic hydrate	70	70	30	250	70		10	300		70
(b1) MAGNIFIN H10										
(b2) HIGILITE H42										
(b3) Magnesium hydroxide										
(b4) Magnesium hydroxide										
(b5) Magnesium hydroxide										
(b6) Magnesium hydroxide										
(C) Hindered phenolic antioxidant										
(c1) Irganox 1010	3	3	3	3	3	3	3	3	3	3
(D) Sulfurous antioxidant										
(d1) NOCRAC MB	5	5	5	5	5	5	5	5	5	5
(E) Metallic oxide										
(e1) Zinc Oxide JIS2	5	5	5	5	5	5	5	5	5	5
Other ingredients										
(x2) Tuftec M1913	10	10	10	10	10	10	10	10	10	10
(y1) Irganox MD1024	1	1	1	1	1	1	1	1	1	1
Flame retardancy	passed	passed	passed	passed	passed	passed	failed	passed	passed	passed
Tensile elongation(%)	400	500	620	150	650	200	650	50	200	140
Tensile strength(MPa)	30	35	41	18	40	20	43	13	14	11
Wear resistance	750	900	1600	250	1500	300	2000	120	130	100
(number of times)										
Flexibility	passed	passed	passed	passed	passed	passed	passed	failed	passed	passed
Workability	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance A	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance B(※)	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance C	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
※ Non-halogenous insulated wire (number of wires)	10	10	10	10	10	5	10	10	10	10
※ Vinyl chloride insulated wire (number of wires)	20	20	20	20	20	20	20	20	20	20

[Table 4]

	Example 16	Example 17	Example 18	Example 19	Example 20	Comparative example 9	Comparative example 10
(A) Non-crosslinked base resin (a1) E-150GM (a' 1) MX002	70 30	70 30	70 30	70 30	70 30	70 30	70 30
(B) Metallic hydrate (b1) MAGNIFIN H10	70	100	90	120	100	70	70
(C) Hindered phenolic antioxidant (c1) Irganox 1010 (c2) Irganox 3114 (c3) Irganox 1076 (c4) ADK AO-80	0.5	10	3	3	3	0.3	15 3
(D) Sulfurous antioxidant (d1) NOCRAC MB	5	5	5	5	5	5	5
(E) Metallic oxide (e1) Zinc Oxide JIS2	5	5	5	5	5	5	5
Other ingredients (x2) Tuftec M1913 (y1) Irganox MD1024	10 1	10 1	10 1	10 1	10 1	10 1	10 1
Flame retardancy	passed	passed	passed	passed	passed	passed	passed
Tensile elongation (%)	500	300	450	400	400	520	250
Tensile strength (MPa)	35	23	32	28	30	36	18
Wear resistance (number of times)	900	600	800	700	700	1200	300
Flexibility	passed	passed	passed	passed	passed	passed	passed
Workability	passed	passed	passed	passed	passed	passed	failed
Heat resistance A	passed	passed	passed	passed	passed	failed	passed
Heat resistance B (※)	passed	passed	passed	passed	passed	failed	passed
Heat resistance C	passed	passed	passed	passed	passed	passed	passed
※ Non-halogenous insulated wire (number of wires)	10	10	10	10	5	10	10
※ Vinyl chloride insulated wire (number of wires)	20	20	20	20	20	20	20

[Table 5]

	Example 21	Example 22	Example 23	Example 24	Example 25	Example 26	Comparative example 11	Comparative example 12	Comparative example 13
(A) Non-crosslinked base resin (a1) E-150GM (a2) BC8 (a'1) MX002	70  30	90 10	40 60	70 30	80 20	80 20	100	95 5	30 70
(B) Metallic hydrate (b1) MAGNIFIN H10	70	70	100	70	70	70	70	70	70
(C) Hindered phenolic antioxidant (c1) Irganox 1010	3	3	3	3	3	3	3	3	3
(D) Sulfurous antioxidant (d1) NOCRAC MB	5	5	5	5	5	5	5	5	5
(E) Metallic oxide (e1) Zinc Oxide JIS2	5	5	5	5	5	5	5	5	5
Other ingredients (x3) FG1901X (x4) Tuftec H1053 (x5) HPR VR103 (y1) Irganox MD1024	10   1	10   1	10   1	 20 1	10  1	 10 1	10  1	10  1	10  1
Flame retardancy	passed	passed	passed	passed	passed	passed	passed	passed	passed
Tensile elongation(%)	400	500	300	500	480	400	600	520	180
Tensile strength(MPa)	30	35	23	35	26	24	40	36	15.2
Wear resistance (number of times)	750	900	600	900	700	600	2000	2500	100
Flexibility	passed	passed	passed	passed	passed	passed	passed	passed	passed
Workability	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance A	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance B(※)	passed	passed	passed	passed	passed	passed	passed	passed	passed
Heat resistance C	passed	passed	passed	passed	passed	passed	failed	failed	passed
※ Non-halogenous insulated wire (number of wires)	10	10	10	10	10	5	10	10	10
※ Vinyl chloride insulated wire (number of wires)	20	20	20	20	20	20	20	20	20

It was shown that the non-crosslinked flame-retardant resin compositions consistent with one embodiment of the present invention respectively not only

possess sufficient flame retardancy, mechanical properties such as tensile elongation, tensile strength and wear resistance, flexibility, and workability, but also deliver sufficient heat resistance over a long period of time while the insulated covering material is not deteriorated even if used in the wiring harness as the insulated covering material covering the mixture of non-halogenous insulated wires and vinyl chloride insulated wires, and further deliver excellent heat deformation resistance.